U.S. PATENT APPLICATION

IN THE NAME OF

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FOR

METAL INJECTING APPARATUS

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METAL INJECTING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention is generally directed to the field of metal injecting apparatus, and more particularly to a plunger tip and plunger rod assembly that promotes water circulation and plunger tip cooling in a cost saving manner.

In addition, the present invention includes an adapter configured to attach to a plunger rod for the purpose of extending or altering the rod for attaching a plunger tip.

Further, the present invention includes a plunger rod featuring a frusto-conical shape or "Y" style returning water passage, thus increasing the ease of water circulation by minimizing water turbulence.

Description of the Prior Art

Typically in the die cast industry, die casters either purchase or manufacture a straight plunger rod with straight internal water lines. As shown in Figs. 1 and 2, one water line is used to deliver incoming cool water to the internal side of the face of the plunger tip for the purpose of cooling this surface, while the second water line is used as a return to allow the now heated water to escape from the plunger tip. The purpose for this cooling cycle is that these plunger tips are used inside a steel or ceramic shot sleeve which is filled with molten aluminum or molten magnesium. This tip is then used to inject or push, the molten aluminum or molten magnesium under high pressures into a die, or mold. The plunger tip then remains under pressure and in contact with the molten metal until the metal solidifies. The plunger tip is then retracted to its starting position and the shot sleeve is once again filled with molten metal and the process of injecting the metal into the die is repeated. This process causes the plunger tip to become hot which could cause the plunger tip to experience premature failure due to

thermal fatigue of the beryllium copper, or thermal expansion and seize inside the shot sleeve if it were not for keeping it cool by using this process.

The problem with current designs of plunger tips and plunger rods is that the return water must find the straight small water exit hole to remove the heated water. This process hinders the free flow of the circulating water causing turbulence. This turbulence reduces the effectiveness of the cooling water. In addition, in the traditional plunger tip designs there is excess material which is used to create wrench flats and/or threads. This excess material creates additional mass to cool and adds cost to the plunger tips.

Attempts to reduce the material mass by making a similar "cap" or shortened plunger tip combined with a traditional style plunger rod, or shot rod have not solved the water flow problem resulting from the small straight return for the heated water.

One design for a plunger rod that threaded entirely to the face of the plunger tip included complex water channels machined into the face of the rod for circulating the water. This design was very costly due to the extensive machining involved with the plunger rod, and still did not allow for free-flowing water throughout the plunger tip.

Another design used a smaller plunger tip or "cap" and a flared water return as part of a pivoting self-aligning plunger tip system. The mechanical pivoting portion of this design was very expensive to manufacture due to multiple precision-machined components. In addition, this device has multiple places which could create problem areas for water leaks. Due to the nature of the die cast process of having water, molten metal, and high pressures, any water leakage can cause quality and possibly safety issues. Therefore die casters stress simple and reliable designs as being preferable.

In the die cast industry, plunger rods are traditionally made of steel and in one piece. A plunger tip is then attached on the end of these plunger rods and used to inject molten metal into a die or mold. As shown in Fig. 2, inside these plunger rods are machined passages for water to flow both into and out of the plunger tip as a method of keeping the plunger tip cool during the process of die casting or injecting molten metal, into a die. The plunger rods traditionally have a straight copper or steel incoming water line which delivers cooling water to the internal face of a plunger tip. In addition, the traditional style plunger rod features a straight return hole, or passage, for the water to

exit the cooling chamber of the plunger tip. This return, or exit hole is slightly larger in area than the incoming water line.

Traditionally if a rod required modification, or is damaged due to the breakage or damaging of the thread, which the plunger tip is screwed onto, it is either scrapped or the water hole in the rod is machined larger and threaded. Then a simple piece of all-thread (a threaded rod) is placed into the threaded hole so that a plunger tip can once again be attached. All of these pieces are traditionally made of steel and with straight water passages.

The above methods of either scrapping the rods and purchasing new rods, or machining them and placing a threaded rod into it for the purpose of once again attaching a plunger tip, are the typical remedies.

The design described above is, and has been, a standard design for over 50 years. There is currently one other "Y" designed water return, however, it is incorporated into a mechanical pivoting (self-aligning) plunger tip system. This self-aligning system is very costly due to extensive precision machining necessary to manufacture the various parts necessary to complete the plunger tip system.

An apparatus is needed that overcomes some of the problems identified above in a safe and cost effective manner.

SUMMARY OF THE INVENTION

It is an object of an embodiment of the present invention to provide the flared "Y" shaped return for the heated water which allows for free-flowing circulation with less turbulence, thus improving cooling. This combined with a smaller plunger tip or "cap" also improves cooling through removing excess material from the plunger tip itself. In addition, there is a cost advantage to this system through the reduced material cost of the plunger tip. The simple design of incorporating the larger threads on the outside diameter of the plunger rod along with the flared "Y" style water return, along with the larger internal threads in the plunger tip, eliminates the excess places for leakage to occur that may be possible with the mechanical self-aligning device. In addition, there is a cost advantage by eliminating the costly precision-machined parts that make up the pivoting portion of the self-aligning device.

It is another object of one embodiment of the present invention to provide an adapter for the purpose of either extending the rod and/or to adapt it to use a shortened plunger tip and/or the "Y" designed water return, rather than scrapping and purchasing or making a new plunger rod. This adapter can be made of a traditional steel, or a preferred beryllium copper alloy.

An advantage of making the adapter from beryllium copper is both in savings by using the current shot rod rather than scrapping it, plus taking advantage of the thermal properties of the beryllium copper material. The beryllium copper is acting as a heat sink in dissipating the heat from the attached plunger tip and passing it onto the circulating water.

Improved cooling created by increased thermal dissipation will allow the plunger tips to run cooler which will cause the molten metal being injected to solidify quicker. This will reduce the cycle times and increase production for the die caster.

It is a further object of an embodiment of the present invention to provide the frusto-conical shaped or "Y" coolant return passage plunger rod design which is much simpler and less costly as it is being machined into a standard one piece shot rod thus eliminating all of the precision machined parts that make up the mechanical "self-aligning" plunger tip system.

Due to the simplicity of this new design, we are greatly reducing possible failure points associated with the mechanical system, plus manufacturing at a greatly reduced cost. This new simpler design may be more desirable by the end user because of the concerns associated with possible water leaks around molten metal.

In addition, since the returning cooling water is now able to freely flow and exit through this frusto-conical shaped or "Y" styled exit hole as compared to the traditional flat faced smaller return hole, there will be less turbulence in the circulating water. This reduced turbulence will cause the cooling water to have greater contact with the cooling chamber thus increasing the efficiency of the water and promoting a cooler running plunger tip.

One embodiment of the present invention includes an adapter for cooperatively engaging a plunger tip and a plunger rod for forcing molten metal from a shot sleeve into a die of a die-casting apparatus. The adapter includes a distal end adapted to

cooperatively engage the plunger tip, an opposite proximal end adapted to cooperatively engage the plunger rod, and a length between the distal end and the proximal end. The adapter has at least one passage extending from the proximal end to the distal end to permit the flow of coolant there through. The adapter is formed of a beryllium-copper alloy to facilitate the transfer of heat from the plunger tip to the coolant passing through the passage of the adapter.

The passage of the adapter is preferably an axial bore, and more preferably the axial bore of the adapter is along a mid-longitudinal axis of the adapter. The passage of the adapter in one embodiment is generally uniform in cross section along the length of the adapter. In an alternative embodiment of the present invention the passage of the adapter has an enlarged cross section adjacent the distal end of the adapter. A preferred embodiment of the present invention has the passage of the adapter having a frusto-conical shape adjacent the distal end of the adapter to facilitate the flow of coolant through the passage and to increase the size of the cooling chamber available to cool the plunger tip. An o-ring may be included between the adapter and the plunger tip and an o-ring may be included between the adapter and the plunger rod.

Another embodiment of the present invention includes a plunger rod having a distal end, an opposite proximal end, and at least one coolant passage extending from the distal end toward the proximal end to permit the flow of coolant there through. The at least one passage of the plunger rod preferably has an enlarged cross section adjacent the distal end of the plunger rod. This embodiment of the present invention also includes a plunger tip having a distal end adapted to contact the molten metal and an opposite proximal end having an inner diameter being threaded to cooperatively engage the plunger rod. The plunger tip has a cooling chamber adapted to receive coolant from the coolant passage of the plunger rod. The passage of the plunger rod preferably has a frusto-conical shape adjacent the distal end of the plunger rod to facilitate the flow of coolant through the passage and to increase the size of the cooling chamber available to cool the plunger tip. An o-ring may be used between the plunger rod and the plunger tip. The plunger tip preferably is formed of a beryllium-copper alloy. The plunger tip preferably has an annular wall adapted for sliding sealing engagement with an internal surface of the shot sleeve. The plunger rod may have an exterior

portion adjacent the distal end that is threaded. The plunger rod is preferably in fixed relation to the plunger tip.

Yet another embodiment of the present invention includes a plunger tip for forcing molten metal from a shot sleeve into a die of a die-casting apparatus. The plunger tip includes a distal end adapted to contact the molten metal, an opposite proximal end having an inner diameter being threaded to cooperatively engage a threaded exterior portion of a plunger rod, and a length between the distal end and the proximal end. The plunger tip has a cooling chamber. The plunger tip preferably is formed of a beryllium-copper alloy to facilitate the transfer of heat from the plunger tip to coolant passing through the cooling chamber. The plunger tip has an outer diameter of at least 5.5 inches and an inner diameter of no greater then 2.0 inches. This embodiment of the present invention also includes one of a plunger rod and an adapter. Either the plunger rod or the adapter has a distal end, an opposite proximal end, and at least one coolant passage extending from the distal end toward the proximal end to permit the flow of coolant there through. The at least one passage has an enlarged cross section adjacent the distal end. The plunger tip preferably has an annular wall adapted for sliding sealing engagement with an internal surface of the shot sleeve.

A further embodiment of the present invention includes a plunger rod adapted for cooperative engagement with an adapter adapted for cooperative engagement with a plunger tip for forcing molten metal from a shot sleeve into a die of a die-casting apparatus. The plunger rod includes a distal end, an opposite proximal end, and a length between the distal end proximal ends. An exterior portion of the plunger rod adjacent the distal end is left hand threaded. The left hand threaded portion of the plunger rod is adapted to cooperatively engage an adapter adapted to cooperatively engage a plunger tip. The plunger rod has at least one coolant passage extending from the distal end toward the proximal end to permit the flow of coolant there through. This embodiment of the present invention preferably includes an adapter having a distal end adapted to cooperatively engage the plunger tip, an opposite proximal end adapted to cooperatively engage the plunger rod, and a length between the distal end and the proximal end. An interior portion of the adapter adjacent the proximal end is left hand threaded to cooperatively engage the left hand threaded portion of the plunger rod. A

portion of the adapter adjacent the distal end is right hand threaded to cooperatively engage the plunger tip. The adapter has at least one passage extending from the proximal end to the distal end to permit the flow of coolant there through. The adapter preferably is formed of a beryllium-copper alloy to facilitate the transfer of heat from the plunger tip to the coolant passing through the passage of the adapter. The passage of the adapter preferably has a frusto-conical shape adjacent the distal end of the adapter to facilitate the flow of coolant through the passage and to increase the size of the cooling chamber available to cool the plunger tip. This embodiment of the present invention preferably includes a plunger tip having a distal end adapted to contact the molten metal and an opposite proximal end having an inner diameter that is right hand threaded to cooperatively engage the right hand threaded exterior portion of the adapter. The plunger tip has a cooling chamber adapted to receive coolant from the coolant passage of the adapter. The passage of the adapter preferably has an enlarged cross section adjacent the distal end of the adapter.

These and other objects of the present invention will be apparent from review of the following specification and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross sectional side view of a prior art plunger rod.

FIG. 2 is a cross sectional side view of a prior art plunger rod, plunger tip, and shot sleeve showing coolant flow into and out of the plunger tip.

FIG. 3 is a cross sectional side view of one embodiment of a plunger tip and plunger rod.

FIG. 4 is a cross sectional side view of another embodiment of a plunger tip and plunger rod.

FIG. 5 is a cross sectional side view of one embodiment of an adapter of the present invention.

FIG. 6 is a cross sectional side view of another embodiment of an adapter of the present invention

FIG. 7 is a cross sectional side view of a further embodiment of an adapter of the present invention.

FIG. 8 is a cross sectional side view of yet another embodiment of an adapter of the present invention.

FIG. 9 is a cross sectional side view of a plunger rod of the present invention.

FIG. 10 is a cross sectional side view of a plunger tip, adapter, and plunger rod of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

One embodiment of the present invention, as shown in Fig. 10, includes an adapter 20 for cooperatively engaging a plunger tip 30 and a plunger rod 40 for forcing molten metal from a shot sleeve 50 into a die of a die-casting apparatus. Adapter 20 includes a distal end 22 adapted to cooperatively engage plunger tip 30, an opposite proximal end 24 adapted to cooperatively engage plunger rod 40, and a length between distal end 22 and proximal end 24. Adapter 20 has at least one passage 26 extending from proximal end 24 to distal end 22 to permit the flow of coolant there through. Adapter 20 is formed of a beryllium-copper alloy to facilitate the transfer of heat from plunger tip 30 to the coolant passing through passage 26 of adapter 20.

Passage 26 of adapter 20 is preferably an axial bore, and more preferably the axial bore of adapter 20 is along a mid-longitudinal axis of adapter 20. As shown in Fig. 7, passage 26 of adapter 20 in one embodiment is generally uniform in cross section along the length of adapter 20. As shown in Fig. 8, in an alternative embodiment of the present invention passage 26 of adapter 20 has an enlarged cross section adjacent distal end 22 of adapter 20. As shown in Figs. 5, 6, and 10, a preferred embodiment of the present invention has passage 26 of adapter 20 having a frusto-conical shape adjacent distal end 22 of adapter 20 to facilitate the flow of coolant through passage 26 and to increase the size of a cooling chamber 32 available to cool plunger tip 30. As shown in Fig. 10, an o-ring 60 may be included between adapter 20 and plunger tip 30 and an o-ring 62 may be included between adapter 20 and plunger rod 40.

As shown in Figs. 3, 4, and 9, another embodiment of the present invention includes a plunger rod 40 having a distal end 42, an opposite proximal end 44, and at least one coolant passage 46 extending from distal end 42 toward proximal end 44 to

permit the flow of coolant there through. Passage 46 of plunger rod 40 preferably has an enlarged cross section adjacent distal end 42 of plunger rod 40. This embodiment of the present invention also includes a plunger tip 30 having a distal end 34 adapted to contact the molten metal and an opposite proximal end 36 having an inner diameter 38 being threaded to cooperatively engage plunger rod 40. Plunger tip 30 has cooling chamber 32 adapted to receive coolant from coolant passage 46 of plunger rod 40. Passage 46 of plunger rod 40 preferably has a frusto-conical shape adjacent distal end 42 of plunger rod 40 to facilitate the flow of coolant through passage 46 and to increase the size of cooling chamber 32 available to cool plunger tip 30. An o-ring 64 may be used between plunger rod 40 and plunger tip 30. Plunger tip 30 preferably is formed of a beryllium-copper alloy. Plunger tip 30 preferably has an annular wall adapted for sliding sealing engagement with an internal surface of shot sleeve 50. Plunger rod 40 may have an exterior portion 48 adjacent distal end 42 that is threaded. Plunger rod 40 is preferably in fixed relation to plunger tip 30.

Yet another embodiment of the present invention includes plunger tip 30 for forcing molten metal from shot sleeve 50 into a die of a die-casting apparatus. Plunger tip 30 includes distal end 34 adapted to contact the molten metal, opposite proximal end 36 having inner diameter 38 being threaded to cooperatively engage threaded exterior portion 48 of plunger rod 40, and a length between distal end 34 and proximal end 36. Plunger tip 30 has cooling chamber 32. Plunger tip 30 preferably is formed of a beryllium-copper alloy to facilitate the transfer of heat from plunger tip 30 to coolant passing through cooling chamber 32. Plunger tip 30 in one preferred embodiment has an outer diameter of at least 5.5 inches and an inner diameter of no greater then 2.0 inches. This embodiment of the present invention also includes one of plunger rod 40 and adapter 20. Either plunger rod 40 or adapter 20 has a distal end, an opposite proximal end, and at least one coolant passage extending from the distal end toward the proximal end to permit the flow of coolant there through. The at least one passage has an enlarged cross section adjacent the distal end. Plunger tip 30 preferably has an annular wall adapted for sliding sealing engagement with an internal surface of shot sleeve 50.

As also shown in Fig. 10, a further embodiment of the present invention includes plunger rod 40 adapted for cooperative engagement with adapter 20 adapted for cooperative engagement with plunger tip 30 for forcing molten metal from shot sleeve 50 into a die of a die-casting apparatus. Plunger rod 40 includes distal end 42, opposite proximal end 44, and a length between distal end 42 and proximal end 44. An exterior portion of plunger rod 40 adjacent distal end 42 is left hand threaded. The left hand threaded portion of plunger rod 40 is adapted to cooperatively engage adapter 20 adapted to cooperatively engage plunger tip 30. Plunger rod 40 has at least one coolant passage 46 extending from distal end 42 toward proximal end 44 to permit the flow of coolant there through. This embodiment of the present invention preferably includes adapter 20 having distal end 22 adapted to cooperatively engage plunger tip 30, opposite proximal end 24 adapted to cooperatively engage plunger rod 40, and a length between distal end 22 and proximal end 24. An interior portion of adapter 20 adjacent proximal end 24 is left hand threaded to cooperatively engage the left hand threaded portion of plunger rod 40. A portion of adapter 20 adjacent distal end 22 is right hand threaded to cooperatively engage plunger tip 30. Adapter 20 has passage 26 extending from proximal end 24 to distal end 22 to permit the flow of coolant there through. Adapter 20 preferably is formed of a beryllium-copper alloy to facilitate the transfer of heat from plunger tip 30 to the coolant passing through passage 26 of adapter 20. Passage 26 of adapter 20 preferably has a frusto-conical shape adjacent distal end 22 of adapter 20 to facilitate the flow of coolant through passage 26 and to increase the size of cooling chamber 32 available to cool plunger tip 30. This embodiment of the present invention preferably includes plunger tip 30 having distal end 34 adapted to contact the molten metal and opposite proximal end 36 having inner diameter 38 that is right hand threaded to cooperatively engage the right hand threaded exterior portion of adapter 20. Plunger tip 30 has cooling chamber 32 adapted to receive coolant from coolant passage 26 of adapter 20. Passage 26 of adapter 20 preferably has an enlarged cross section adjacent distal end 22 of adapter 20.

The water return hole is flared for improved water circulation and to increase the return cooling water's surface area for maximum heat transfer. This allows for additional opportunities for the cooling water to absorb and carry away heat. Another

advantage of this design is the transfer of a portion (up to 50%) of the cooling chamber that would normally be in plunger tip 30, back into adapter 20. This feature allows the use of a heavier than normal sidewall thickness in plunger tip 30 which allows for extra turndowns and greater value to the customer. By transferring a portion of the cooling chamber into adapter 20, we can offer roughly the same surface area for cooling water contact as would be found in a plunger tip more than 2 inches longer than the tips use by an embodiment of the present invention.

The plunger tips have been opened up to allow for greater water flow and cooling. The hex design restricts the area available for such a flared return and restricts open water circulation, so the hex design on plunger tip 30 has been eliminated in a preferred embodiment. In addition, in a typical plunger rod/plunger tip design, the steel rod extends into plunger tip 30 creating a heavy mass of steel and copper to try to cool.

The problems associated with using a small cooling chamber in a standard tip design to allow for the same additional turndowns, is both the restricted water flow, and the heavy wall thickness created by the combination of plunger tip 30 hex and the steel plunger rod threads. These conditions cause the tips to run hot, thereby leading to premature failure caused by thermal fatigue in the plunger tips.

By taking advantage of the thermal properties and design of the beryllium copper adapter acting as a heat sink, a thicker than normal sidewall in plunger tip 30 may be provided. This design allows for additional turndowns as compared to traditional tip designs.

In addition, in cases where customers may have similar tip diameters, but of different lengths, we can adjust the lengths of the rod or adapter to allow for the tips to be used for multiple applications. This also creates additional savings.

Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.